

AN ANALYSIS OF THE CAUSATIVE FACTORS OF THE FEBRUARY 1962 FLOODS IN UTAH AND EASTERN NEVADA

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ABSTRACT

The floods in Utah and eastern Nevada during February 1962 resulted in lower valley flooding in Utah and record-breaking crests on the upper Humboldt River in Nevada. Records of temperature, precipitation, snow cover, and soil temperatures, as well as synoptic weather patterns were studied. Accumulated freezing degree days were used as an index to the depth of frost penetration in the soil. The most significant single factor contributing to the flooding was the near-record depth of frost penetration which prevailed in the valleys prior to the flooding. The water equivalent of the snow pack together with the rains that accompanied the warm weather provided an unusual amount of water for the flooding.

1. INTRODUCTION

During February 1962 flooding occurred in various sections of Utah, Idaho, and eastern Nevada, which resulted from a combination of several hydrologic and meteorological factors. The purpose of this discussion is to analyze the various factors which contributed to the flooding. The material presented applies to Utah and Nevada, although the same principles might be applicable to the Idaho flood area. Regions in Utah and eastern Nevada, where flooding occurred, are shown by cross hatching on the map in figure 1. Three regions—the Humboldt River Basin in Nevada, and the Gunnison area and Heber Valley in Utah—are used for purposes of illustration.

2. GENERAL DISCUSSION

Flooding during the winter season is unusual in Utah and eastern Nevada. In Utah, most previous occurrences have resulted chiefly from rains of heavy intensity, whereas in northeastern Nevada, winter flooding has been caused primarily by snow melt. An excellent example of a snow melt flood was that of February 1943 on the upper Humboldt River.

The floods of February 1962 were, in all cases, the result of various combinations of rain and snow melt over frozen ground. Most of the flooding in Utah was not the result of overflowing streams, but occurred where the runoff was confined in rather small drainage basins. In Nevada, because of a much larger drainage area between 5,000 and 6,000 feet elevation, the total amount of water was much greater, and record-breaking crests were observed on the upper Humboldt River.

3. SYNOPTIC SITUATION

One of the many synoptic factors leading to the flood situation was the precipitation that occurred during August and September 1961, which did much to replenish the soil moisture. Air temperatures averaged well below normal from September on, minimizing evaporation from the soil, even though November precipitation was below normal.

December temperatures reached near record minimum values around the 11th of the month, prior to a period of general snow cover that persisted in some of the flood

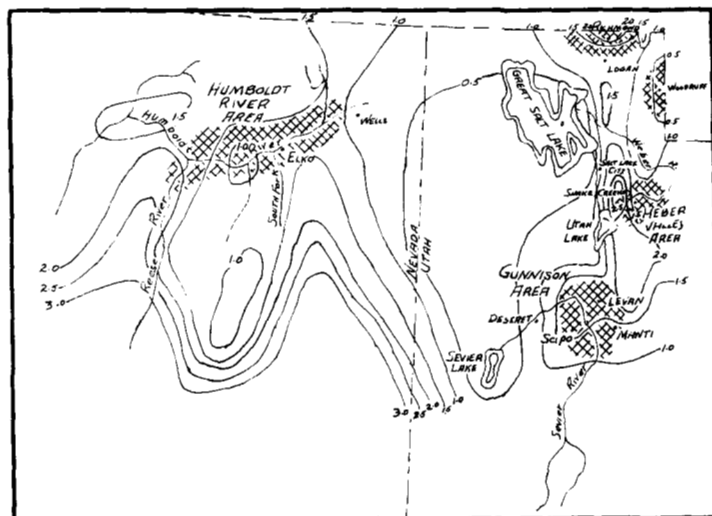


FIGURE 1.—Isohyetal map (in inches) of northern Utah and northeastern Nevada for period February 7-13, 1962. Areas of flooding shown by cross hatching.

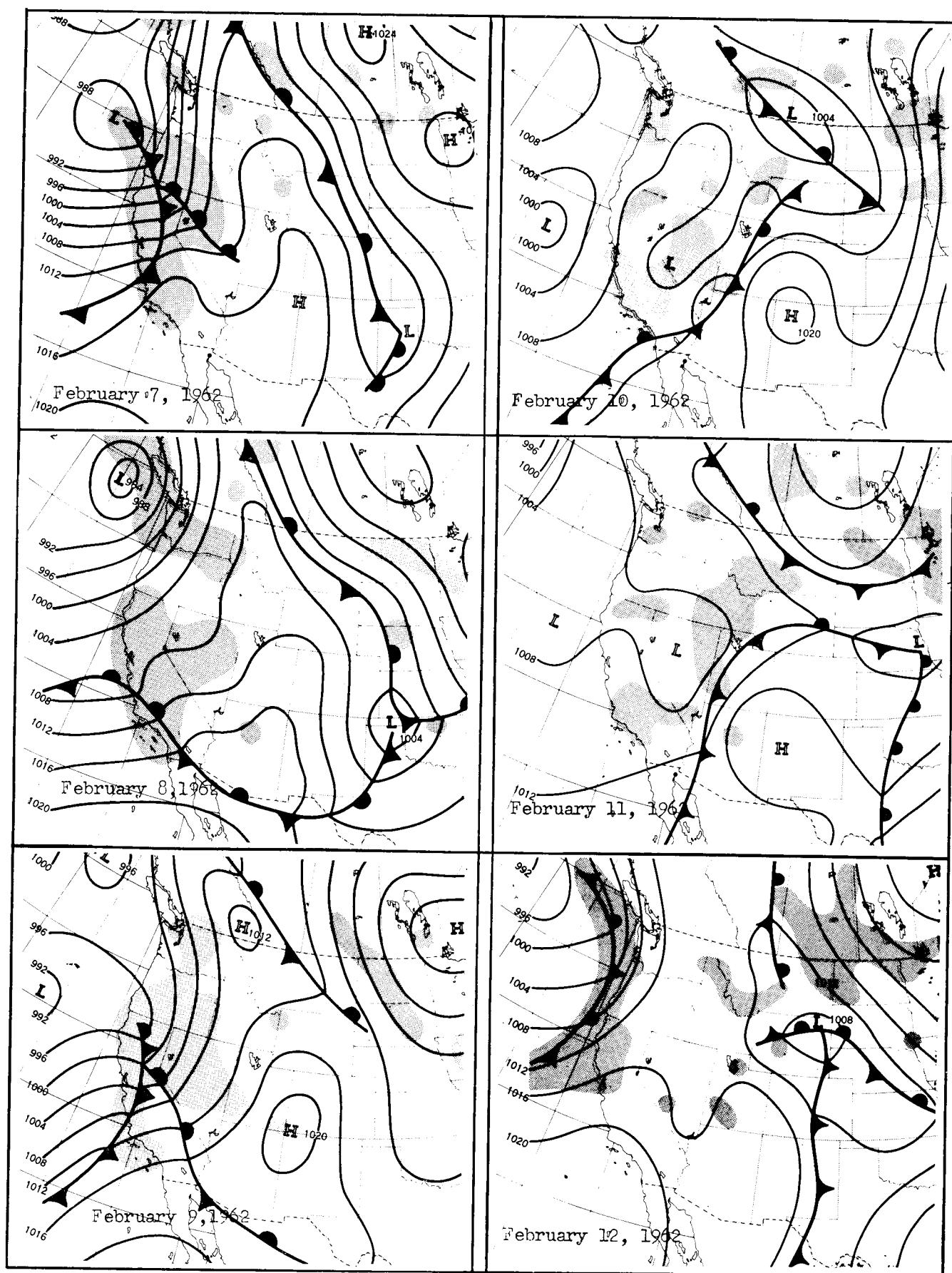


FIGURE 2.—Surface weather maps, 1100 MST, February 7–12, 1962, showing synoptic situation prior to and during flooding.

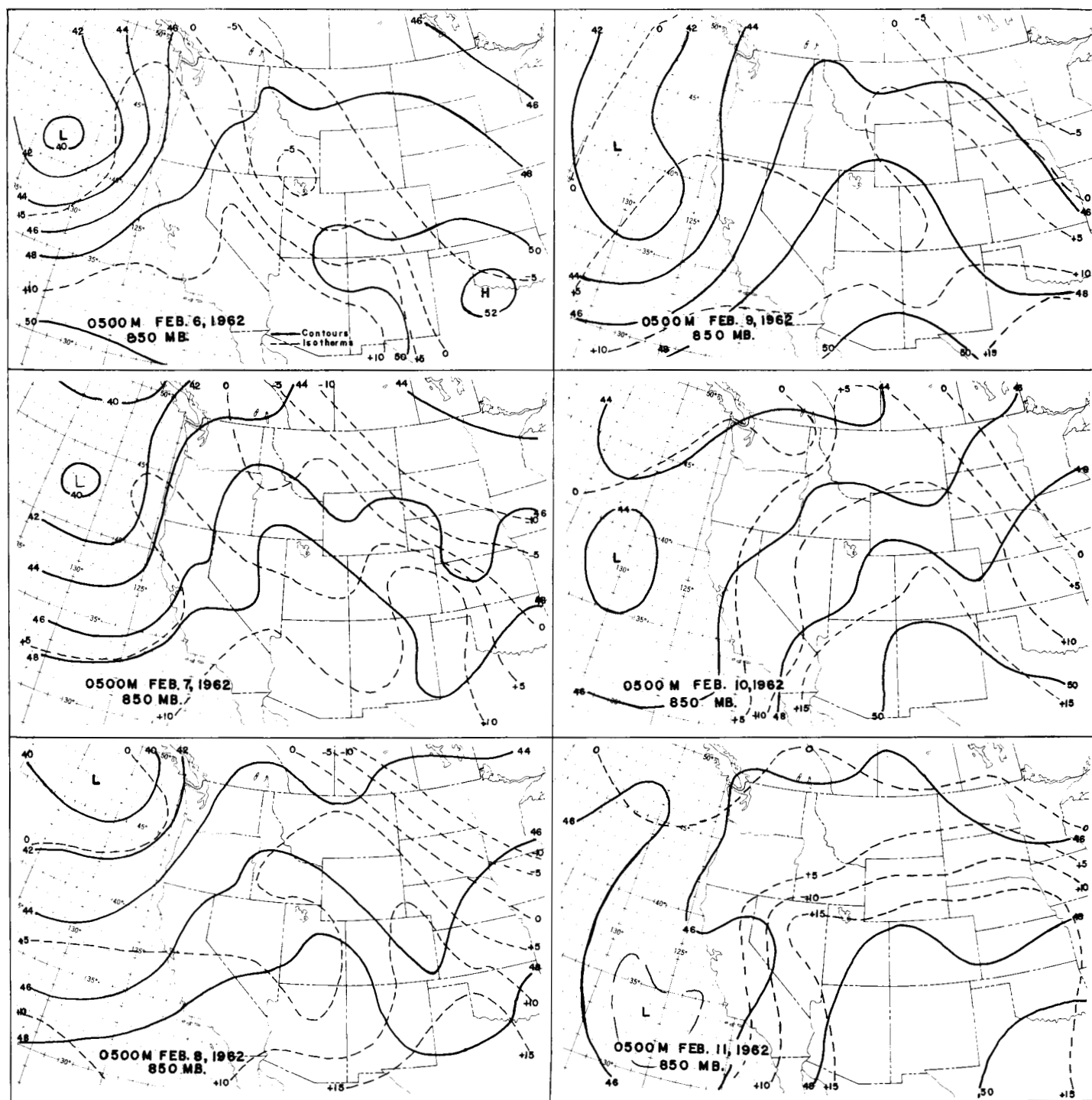


FIGURE 3.—850-mb. charts, 0500 MST, February 6–11, 1962, showing contour and temperature patterns.

areas during the remainder of the month. Only a few days at a time elapsed during December without measurable precipitation. Less than 50 percent of possible sunshine was recorded at the Salt Lake City airport during December and January. An unusually cold air mass and lack of sunshine produced a total of 414 freezing degree days between January 7 and February 6 at the Salt Lake City airport. Freezing degree days as used in

this report are defined as the difference of the mean daily temperature from 32° F. and are considered positive when the mean temperature is below 32° F. and negative when above. Their cumulative effect is related to their sum which increases during cold weather but decreases during thaws (see fig. 4).

During the latter part of January, a stagnant high pressure system developed over the Great Basin. The

TABLE 1.—Temperature and precipitation data for selected stations

A. HEBER VALLEY AREA, UTAH

Date 1962	Heber, Utah				Snake Creek, Utah			
	Max. temp. (° F.)	Min. temp. (° F.)	Precip. (in.)	Snow cover (in.)	Max. temp. (° F.)	Min. temp. (° F.)	Precip. (in.)	Snow cover (in.)
Jan. 1	30	-2		5	32	2		
2	31	-6		5	30	0		
3	30	-2		5	32	2		
4	40	16		5	36	18		
5	33	4		5	31	7		16
6	33	17	0.07	5	28	18	0.19	
7	40	30	.17	5	38	30	.44	17
8	38	32	.48	4	34	33	.92	15
9	35	14	.02	4	37	10	.17	15
10	14	-8		4	25	-12		
11	22	-4		4	18	-11		
12	32	5		4	37	2	.02	
13	30	16	.02	4	26	15	.02	
14	24	-2		4	24	0		
15	27	-4	Tr.	4	27	-2	.01	
16	27	-5		4	27	-4		
17	27	-5		4	30	10	Tr.	
18	30	8	.02	4	28	18		
19	28	18	.30	7	38	20	.20	28
20	39	22	1.36	19	38	20	.90	29
21	25	10	.16	18	30	7	.15	31
22	15	-13		18	11	-14		31
23	12	-28		18	14	-18		30
24	17	-22		18	18	-12		30
25	25	-11		18	23	-5		28
26	29	-2		18	30	4		25
27	32	0		17	33	5		29?
28	34	-5		16	31	4		27?
29	31	-7		16	33	2		26
30	35	-6		16	35	5		25
31	33	-5		15	36	5		25
Feb. 1	36	-3		15	38	7		
2	39	0		14	40	10		
3	40	1		12	41	13		
4	38	1		11	38	8		
5	38	-4		10	41	9	Tr.	
6	34	-2		10	46	29		
7	44	17	Tr.	9	46	24		
8	39	18	.27	9	44	24	.39	
9	43	30	.15	9	42	31	.37	23
10	49	36	.16	7	50	34	.59	
11	52	38	.27	5	53	35	.44	21
12	50	32	.30	2	50	32	.37	
13	50	27		2	45	25	Tr.	18
14	45	31	.10	2	43	30	.13	
15	41	25	.12	2	40	30	.34	

TABLE 1.—Temperature and precipitation data for selected stations—Continued

B. GUNNISON AREA, UTAH

Date 1962	Levan, Utah				Manti, Utah			
	Max. temp. (° F.)	Min. temp. (° F.)	Precip. (in.)	Snow cover (in.)	Max. temp. (° F.)	Min. temp. (° F.)	Precip. (in.)	Snow cover (in.)
Jan. 1	35	3		4	36	8		2
2	35	0		4	35	7		2
3	36	4		4	39	7		2
4	37	21	0.03	5	38	19	Tr.	2
5	39	10		5	35	10		2
6	38	17		4	42	15		1
7	45	33	.08	3	49	34	0.08	Tr.
8	45	37		2	45	38		Tr.
9	44	21		2	42	22		Tr.
10	28	2		2	20	0		Tr.
11	30	3		2	28	2		Tr.
12	36	9		2	40	10		Tr.
13	35	21	.37	7	36	22	.40	7
14	28	-1	.08	7	25	4	Tr.	5
15	30	-5		6	29	-2		4
16	31	-2		6	31	-2		4
17	34	0		6	33	0		3
18	32	9	.01	6	34	11	Tr.	3
19	34	20	.38	12	39	22	.25	6
20	43	22		6	43	26	Tr.	4
21	42	10	1.29	12	25	16	.56	9
22	15	0		10	17	-3	.02	8
23	15	-16		10	14	-13		8
24	18	-17		9	19	-10		8
25	25	-8		8	21	-6		8
26	36	6		7	37	2		7
27	37	8		7	38	10		7
28	35	3		7	39	7		7
29	33	2		7	41	7		7
30	32	1		7	35	7		7
31	30	2		6	42	7		7
Feb. 1	34	0		7	39	9		7
2	37	6		7	45	12		6
3	45	12		7	48	16		5
4	47	12		7	50	17		4
5	47	14		7	45	15		4
6	48	15		6	44	15		3
7	47	26		6	45	25	Tr.	3
8	41	27	.16	4	40	28	.33	2
9	43	33	.65	3	42	32	*.54	2
10	48	37		2	57	34	(*)	Tr.
11	60	40		1	61	46		Tr.
12	56	33	.88	Tr.	52	33	.56	Tr.
13	53	29		Tr.	48	28	Tr.	Tr.
14	52	33			50	30	Tr.	Tr.
15	49	29	.07		42	27	.06	Tr.

* Extreme runoff from snow-rain; ground still frozen.

inversion associated with this extensive area of high pressure resulted in the formation of heavy fog over northwestern Utah and patchy fog in northeastern Nevada. This fog persisted until February 7 in the valleys of Utah and not only prevented evaporation but resulted in increased moisture through direct condensation.

About February 7, the high pressure cell began breaking down, allowing Pacific frontal systems to move inland across the intermountain area. The first in a series of waves moved into northern Utah during the early morning of February 8, with another wave developing off the central California coast. The synoptic pattern which followed resulted in general precipitation over the Great Basin through the 13th. Figure 2 shows the series of daily surface maps prior to and during the flood period.

The upper-air trough associated with the surface frontal systems, moved southward along the west coast, causing the flow aloft to become more and more southerly. Advection of warm, moist air caused temperatures to rise rapidly during the storm period, particularly in the levels between the surface and 700 mb. The series of 850-mb. charts for February 6 through 11 illustrate this marked

advection. As shown in figure 3 temperatures at 850 mb. in the flood areas increased from -5°C . to 0°C . on the 6th, to $15^{\circ}\text{--}18^{\circ}\text{C}$. or about 60°F . by the morning of February 11. Also indicative of the sudden increase in temperature was the change in height of the freezing level from near the surface to approximately 11,000 feet by February 11 at Salt Lake City.

Table 1 is a tabulation of maximum and minimum temperatures, precipitation, and snow depths for two representative stations in each flood area. The minimum temperatures did not rise above freezing from January 9 until February 9. Maximum temperatures were above freezing during most of late January and early February, but the minimums below 32°F . prevented much loss of water from the snow cover.

4. RUNOFF SOURCES

Most of the precipitation which fell as snow during January in the flood areas was still on the ground when the warm rains occurred. Elko, Nev., recorded 0.81 inch precipitation during the 30 days prior to the flood, and

TABLE 1.—*Temperature and precipitation data for selected stations—Continued*

C. UPPER HUMBOLDT BASIN, NEVADA

Date 1962	Elko, Nevada				Wells, Nevada			
	Max. temp. (° F.)	Min. temp. (° F.)	Precip. (in.)	Snow cover (in.)	Max. temp. (° F.)	Min. temp. (° F.)	Precip. (in.)	Snow cover (in.)
Jan. 1.	40	18			42	15		
2.	43	15			41	6		
3.	48	18	Tr.		47	10		
4.	41	19			39	26		
5.	43	14			41	10		
6.	47	38	Tr.		48	24	Tr.	
7.	48	41			50	39	Tr.	
8.	49	38	Tr.		48	37		
9.	42	18			44	22		
10.	30	11			26	1		
11.	36	7			37	1		
12.	29	15	0.18		7	7	0.07	1
13.	27	-2	.01		16	0	.03	1
14.	24	-13		3	28	0		1
15.	31	-3	Tr.		33	5	Tr.	1
16.	27	-10	Tr.		27	-9		1
17.	27	-3			32	-5		
18.	30	16	.10		29	12	.03	2
19.	36	20	.40		30	17	.16	5
20.	38	-3	.12	8	32	14	.44	11
21.	10	-22		9	15	-11		11
22.	14	-22		9	10	-14		11
23.	7	-24		8	3	-22		11
24.	15	-17		8	19	-17		11
25.	26	-1		7	7	3		11
26.	36	15		7	11			10
27.	29	6	Tr.	7	28	-1		10
28.	31	2	Tr.	7	23	-1		10
29.	27	-1	Tr.	7	23	-1		9
30.	29	-4	Tr.	6	22	-4		9
31.	26	-3	Tr.	6	30	-6		Msg.
Feb. 1.	31	-3	Tr.	6	39	2		8
2.	38	0		6	42	4		8
3.	33	2	Tr.	6	42	3		7
4.	40	4		6	47	9		7
5.	41	9		6	45	10		7
6.	37	10	Tr.	6	39	10	Tr.	6
7.	40	15	.04	5	40	17	.09	4
8.	38	20	.01	5	37	22	.06	4
9.	46	31	.15	4	45	29	.12	3
10.	44	32	.59	2	45	33	.02	2
11.	52	32	.15	Tr.	48	35	.08	Tr.
12.	44	30	.25		44	33	.20	Tr.
13.	45	30	.04		44	26		Tr.
14.	50	30			48	33	.01	Tr.
15.	49	32	.26		44	31	.18	Tr.

had approximately 6 inches of snow on the ground, with a water equivalent of 0.75 inch on February 6. Precipitation during the flood period, February 7–13, 1962, varied considerably over Utah and eastern Nevada; some areas reported over 3 inches. An isohyetal map for the 7-day period is shown in figure 1. The amount of precipitation received by selected stations during the 30 days prior to the flooding and the period covered by the isohyetal map are tabulated in table 2. Included in the table are computed values of the total water available for runoff obtained by adding the estimated water equivalent of the snow cover to the total precipitation during the flood period. The estimates of the water equivalent of the snow cover were determined by considering changes in depth of snow cover, the altitude of the stations, and observed temperatures. Most of the water originated at elevations between 5,000 and 6,000 feet, with some runoff from higher elevations.

In Nevada, all of the snow cover at Elko disappeared during the flood period, but at Wells a trace of snow remained on the ground following the flood. In Utah,

TABLE 2.—*Amount of precipitation (in.) at selected stations prior to and during the February 1962 flood*

Station	Elevation (ft.)	Precipitation 30 days prior to flood (in.)	Precipitation during flood period (in.)	Estimated total available water (in.)
Humboldt Basin, Nev.:				
Elko.....	5,075	0.81	1.23	1.98
Wells.....	5,633	0.73	0.61	1.25
Gunnison area, Utah:				
Levan.....	5,300	2.13	0.71	1.90
Manti.....	5,585	1.23	0.87	2.00
Heber Valley, Utah:				
Heber.....	5,593	2.60	1.15	3.50
Snake Creek.....	5,950	3.02	2.16	5.00

Heber reported 2 inches of snow still on the ground following the flood, compared with 10 inches immediately prior. Snake Creek, at a higher elevation and in a protected valley, reported 23 inches of snow cover prior to the flood and 18 inches on the afternoon of February 13. In the Gunnison area, snow cover was completely removed at Levan, with a trace remaining at Manti.

5. SOIL CONDITIONS

A knowledge of the general soil conditions with respect to temperature gradients and moisture content in the flood areas is difficult to obtain. Available reports indicate that the ground was frozen underneath the snow pack. The depths of frost penetration are not known. Reports from Evanston, Wyo., and Woodruff, Utah, indicate that the ground was frozen to a depth of 6 feet, possibly a record in this portion of the country.

In 1930 Alter [1] collected frost data from various areas in Utah and summarized the information in an unpublished report. These data, covering a period of many years, were obtained from graveyard sextons, waterworks superintendents, and various construction crews who had occasion to dig through the frost barrier at intervals. The average and estimated maximum depths for selected stations as determined by Alter are reproduced in table 3.

The only extended record of soil temperature in either Utah or Nevada is that made by the American Smelting

TABLE 3.—*Average and estimated maximum depths of frost penetration for selected stations in Utah as determined by Alter [1]*

Station	Average depth (inches)	Estimated maximum depth (inches)
Deseret.....	12	18
Heber.....	12	24
Logan.....	24	64
Manti.....	16	30
Richmond.....	9	36
Scipio.....	21	24
Salt Lake City.....	(*)	34

* "The average depth depends entirely upon the nature of the ground and whether there is snow cover or not. We find in Salt Lake City that under roadways and paved streets, which have been cleared of snow, the freezing will penetrate much deeper than behind the curbing where there is no traffic and where there is usually some snow cover during our coldest weather. The average depth in the Salt Lake City area is about six inches to two feet six inches."

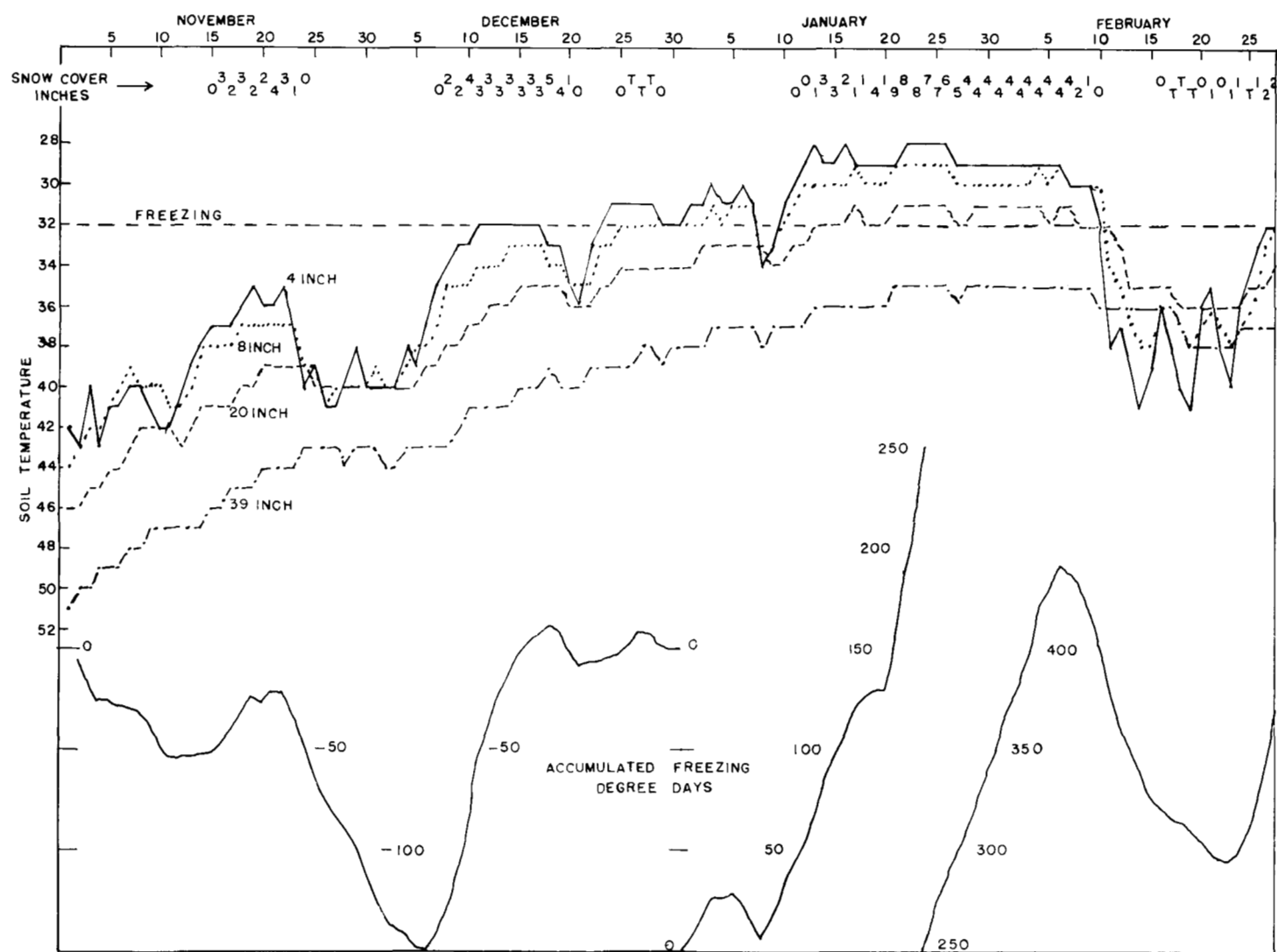


FIGURE 4.—Time cross-section of accumulated freezing degree days and soil temperatures at depths of 4 inches, 8 inches, 20 inches, and 39 inches, for period November 1961 through February 1962, in Salt Lake Valley.

and Refining Company at Salt Lake City, Utah. Table 4 shows the computed maximum depth of frost penetration and months of occurrence for all years of record since 1951.

The 30-inch depths of frost in early February 1962 exceeded any depths for the preceding 11 years; and in view of the estimated maximum depth reported in table 3, should have been at least a near record. The frost in

the soil disappeared in most areas within about 3 days after the flooding began; and as the frost barrier to infiltration of the water disappeared, the flooding diminished. Over an inch of rain fell near February 15 in the Gunnison-Manti drainage but, even through the soil was near saturation, no flooding was reported.

The relationship between accumulated freezing degree days and frost penetration in Salt Lake Valley is shown on a time cross-section (fig. 4). While the soil temperature observations were not made in the area where flooding occurred, they should be somewhat representative of the valleys which were flooded. The plotting of figure 4 shows that the soil temperatures at all measured levels decreased rapidly during periods with an increase in accumulated freezing days, except when the snow cover on the ground was 1 inch or more. With snow cover, even large accumulations of freezing degree days had little effect on the soil temperature. For example, a total of 374

TABLE 4.—Computed maximum depth of frost penetration, 1951–1962

Calendar year	Depth (inches)	Month	Calendar Year	Depth (inches)	Month
1951.....	9	February	1957.....	13	January
1952.....	12	February	1958.....	15	December
1953.....	9	December	1959.....	18	January
1954.....	11	December	1960.....	20	December
1955.....	8	March	1961.....	25	January
1956.....	11	December	1962.....	30	February
			Average.....	15.1	

freezing degree days were accumulated between January 13 and February 6, but no significant change was observed in the soil temperature at any of the observed levels. The data from December 8–15 show that with temperatures of the soil at above freezing, the soil temperatures continued to fall after the ground was covered with snow, until frost penetrated the upper levels of soil. It seems reasonable that with soil temperatures above 32° F. there should be a continued lowering of these temperatures until an equilibrium condition is established with the snow cover. The depth that the 32° F. isotherm will penetrate is dependent upon moisture content of the soil, soil type and compaction, ground slope, the insulating cover of snow or vegetation, and the ambient air temperatures.

6. CONCLUSIONS

The floods in the Utah-Nevada area in February 1962 were the result of several factors. The first of these was the near-record precipitation during early fall, which increased the soil moisture to above normal amounts. Subsequent temperatures averaged well below normal and with only intermittent snow cover at lower elevations, from 5,000 to 6,000 feet, frost penetration reached near record depths at these elevations by the middle of January.

During the latter half of January, considerable snow fell

on the frozen ground. The water equivalent of this snow cover was retained on the ground as a result of the below-normal temperatures and heavy fog which covered most of the intermountain area during the latter part of January and early February. The warming trend during the second week of February with high dew points rapidly melted the snow pack and this coupled with heavy rains made considerable water available for runoff. The latent heat released by this condensation would have been available for melting and ripening of the snow pack.

The most significant single factor contributing to the floods was the depth to which the soil was frozen. If the ground had not been frozen to such depths, it is believed that the available water would not have resulted in nearly the degree of flooding. This is supported by the fact that over an inch of rain occurred during the next week in some of the flood areas when the ground was exceptionally wet but unfrozen, yet no additional flooding was reported.

Additional soil temperature reports from the intermountain area should aid a great deal in forecasting this type of flood condition.

REFERENCE

1. J. C. Alter, "Frost Penetration in Utah", unpublished report Salt Lake City, 1930.

New Weather Bureau Publication

Technical Paper No. 44, "A Catalog of 100 FCC-Positioned Transosonde Flights," by J. K. Angell, Washington, D.C., 1962, 291 pp. For sale by Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.; Price \$2.00.

For each flight the data presented consist of a trajectory map and two contour and isotherm maps near the beginning and end of the flight; a tabulation of the time of positioning, location pressure, fix accuracy, wind speed and direction, and derived ageostrophic wind components; and a graph showing variation with time of transosonde-derived wind speed and ageostrophic speed. Flights were made between April 1953 and May 1959, at levels of 300, 250, and 150 mb.